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CASTING PROCEDURE, PARTICULARLY FOR ENGINE CYLINDER HEAD

Field of the invention

The present invention relates in general to the technology for producing cast parts. In particular, it relates to gravity chills and low-pressure processes that use cores to obtain inside cavities in the casting. A typical example of such casting process is that used for obtaining engine cylinder heads, where internal cores are necessary for obtaining the water jacket for the engine cooling water, the intake and exhaust ducts, and any other secondary cavity.

Prior Art

Generally, for medium and large productions the casting of an engine cylinder head is performed using a fixed outside mould, called chill, whereas inside and sometimes outside as well, cores are required, which are inserted (assembled) into the chill to form a single body ready for casting.

In a casting process by chill with sand and polymerised resin cores, the main difficulty consists in perfectly collimating the inside of the part to be cast, that is the cores, with the outside, that is the chill, so as to obtain the required dimensional accuracy. The cores are obtained in corresponding moulds,

called core boxes, and then they are normally pre-assembled in the proximity of the chill.

The group of pre-assembled cores is collected by automatic devices (grippers and jigs) and laid (assembled) into the chill. At this point it is possible to cast the molten metal which will fill the volume comprised between the sand cores and the chill.

Sand projections, called prints, are obtained onto the cores to keep the core group assembled in the desired position. Such prints are laid into the chill and do not constitute part of the object resulting from the casting. In the specific case of cores for intake and exhaust ducts of an engine cylinder head, whose surfaces form the end shape of the casting, such cores are inserted into the water jacket core and during the step of moving the cores group to the chill, if the assembly is performed manually they are free due to the effect of the gaps that will be occupied by the metal thickness. Then, they laid by gravity into the lower zone of the corresponding passages provided into the water jacket core. When the duct cores are in contact with the drag (lower base) of the chill, they get the final position.

When core assembly is performed with automatic systems, the ducts cores are held into suitable positions relative to the water jacket by a special automatic device, but normally only by the

side of the flange coupling to the intake and exhaust manifolds. The entire operation requires an approach that should be carried out carefully.

Since traditional technology provides for the water jacket core to be moulded separately from one another, as for the other cores, the water jacket core box interior must also be provided with all of the other parts resulting from the outside thickness of the cast-internal parts (ducts, etc.) and that are intended to house – during the subsequent core assembly – the other cores. However, since the ducts outside parts do not undergo drafting as they normally are at half the height of the water jacket, mobile parts are currently used, controlled by gears, camshafts or, in the best case, by pneumatic cylinders, almost always moving on inclined axes.

In case of an engine cylinder head, in order to ease the extraction of these moving parts it is necessary to impart a greater inclination (draft angle) and deform the outside thickness of the ducts, providing excess material to obtain the minimum thickness required by the casting operation. This implies reducing the water jacket core, with the result of a higher brittleness of the same and a lower efficiency of the cooling circuit.

In other cases, the problem of making the duct cores pass through the openings obtained in the water jacket cores is solved by dividing the latter horizontally into two halves, which are then attached to each other by an adhesive after inserting the ducts.

However, this implies higher production costs and lower quality of the finished product, above all due to the casting flashes that may generate into the water circulation compartment, and due to casting blowholes that may develop from the possible contact of molten metal with the half-core fixing adhesive.

Another casting process, called Lost Foam, consists in realising multiple polystyrene sectors using special dies. Once such sectors have been attached to one another, they match the part to be cast. The polystyrene model thus obtained is coated and then put into a container, which is then filled by vibration with common sand or a similar material. Using a special pouring channel, made of polystyrene as well, the molten metal is poured into the container. As polystyrene burns, it is replaced by the metal, so as to form the desired casting.

This process allows eliminating the realisation and laying of polymerised sand cores. On the other hand, however, besides the various technological problems, it also exhibits the

disadvantage – in the case of an engine cylinder head casting – that the duct shapes, even though coated, are not optimal since their surfaces are moulded and therefore directly finished by the polystyrene surfaces. They may even exhibit junctions resulting from the coupling of polystyrene sectors. The necessary use of glue, moreover, is the primary cause of blowholes. In substance, this process is scarcely used.

Objects and advantages of the invention

Object of the present invention is to obviate the disadvantages of the prior art mentioned above, by proposing a new casting procedure which allows obtaining higher quality castings, thereby reducing the number of the cast scrap due to dimensional defects, and further introducing new design prospects.

another object of the invention is to provide a casting procedure which allows a perfect relative positioning between each core and an easy insertion of the cores into the mould or into another core, whichever their shape.

Another object of the finding is to provide a casting procedure which allows a considerable simplification of the core boxes, that is, without any complex shapes, undercuts and connected moving parts, and which is therefore cheaper, more reliable and easier to maintain.

Another object of the invention is to provide a chilling casting process for engine cylinder heads which allows obtaining cores for intake and exhaust ducts without any deformation on the outside thickness and with the most varied and complex shapes, which may result in better engine performance and ecologically more advanced engines as regards exhaust gases, as allowed by the new casting technology.

Yet another object of the invention is to provide a casting procedure for engine cylinder heads which allows embedding inserts for the ducts into the casting, made of a material capable of standing the heat generated by the molten metal in order to obtain perfectly smooth ducts which should contribute to improving the engine efficiency.

These and other objects of the invention are achieved by a casting process according to the claims hereinafter.

Brief description of the drawings

Further features of the invention will appear more clearly with reference to the attached indicative and non-limiting drawings. In such drawings:

- Figure 1 shows sand and polymerised resin cores for realising the intake and exhaust ducts of an engine cylinder head;

- Figure 2 shows a section view of the core boxes for moulding

the cores of Fig. 1, in a variant with inserts around the intake and exhaust ducts;

- Figure 3 shows the duct cores with inserts obtained with the core box of Fig. 2;

- Figure 4 shows a section of the duct cores inserted into the die for their coating with foamed material;

- Figure 5 shows the group of valve seats and duct cores coated with foamed material;

- Figure 6 shows the water jacket core box still empty;

- Figure 7 shows the core box (fig.6) with the group of duct cores of Fig. 5 inserted therein;

- Figure 8 shows the group of cores, valve seats and foamed coating obtained by moulding the water jacket core in the core box of the previous Figure, with the valve guides inserted into the coating;

- Figure 9 shows a complete chill core assembly scheme of the core group of the previous Figure;

- Figures 9a and 9b show two enlarged details of the core assembly scheme, where black parts denote the difference in the shape and volume of the water jacket dimensions that can be obtained by the casting procedure under discussion compared to the current art;

- Figure 10 shows the core assembly scheme in the variant with inserts.

Detailed description of the invention

As said above, the present invention relates to a casting procedure for obtaining castings provided with inside cavities. As known, such cavities are obtained by laying in a mould, such as a chill, intended to receive the molten metal, one or more cores made or sand and polymerised resin or other material. Such cores, in turn, are previously obtained into special moulds, called core boxes. In the case of more cores, these are obtained separately, each into a relative core box, and then they are assembled each other before being laid (assembled) into the mould or chill. To this purpose, the cores are usually provided with complementary projections and cavities, called positive and negative prints, to support one another, and with other sand projections intended to lay into the suitable seats into the chill, which do not form part of the casting.

The procedure according to the present invention provides for coating one or more cores made of sand or other material with a layer of foamed material, such as polystyrene, only in the shaped zones, using a special die and then laying them into the chill.

The core coating material is intended to dissolve in contact with the casting metal, which replaces it thereby determining

the required casting thickness, so that the finished casting surface will be determined by the quality of the core surface.

In particular, the procedure under discussion has been conceived and is especially advantageous in casting processes that require the realisation of a main core and of one or more secondary cores. According to the finding, after being realised in the usual way into respective core boxes, such secondary cores are laid into a die and coated with foamed material only in the shape zone, with the thickness required by the casting, and then they are laid (pre-assembled into the main core box yet to be moulded, that is, empty.

In order to receive the secondary cores already coated with foamed material, the main core box will be empty at the shapes of said secondary cores since shapes and thickness are replaced by the cores and by the coating layer. As a consequence, the main core box is much easier and cheaper to be realised since it allows eliminating any inside undercut and any moving parts required to realised the containments of secondary cores. In addition the main core box only has the outside prints of the secondary cores, which will be pre-assembled into the same. Following the moulding of the main core box with sand and polymerised resin, a single monolithic body is obtained, already assembled and exhibiting a considerable geometric accuracy, consisting of the main core

and of the secondary cores, which are integral with the main core through the coating that forms the casting thickness.

Such monolithic body can then be easily carried and laid into the mould or chill.

Besides cores of sand or of other material, the casting procedure under discussion can be applied to thin hollow inserts consisting of heat resistant material, such as metal or composite material, and intended to be embedded into the casting for making the inside surfaces of the cavities perfectly smooth. From the dimensional point of view, the main core box is capable of receiving both sand cores or inserts coated with foamed material.

If inserts of metal or other material are to be embedded into the casting, and these inserts have an inside void and where such void is corresponding to the core design, they must be laid into a specific core box which only considers the insert thickness in addition, and then it is moulded. The resulting core will be provided with prints and embedded inserts, only in the shaped zone, and besides serving as support for the inserts, such core will also prevent the molten material from penetrating into the void part of the embedded inserts.

The property that allows performing the pre-assembly of already coated cores into a core box yet to be moulded (void)

allows, for such a secondary cores to be conformed in any geometrical shape which would otherwise be not possible. In the casting it is therefore possible to obtain even several passages, labyrinths and else which was not possible before, and this since it is not necessary anymore to perform a successive assembly, only after moulding all cores.

Consequently the described process results in outside thickness of all secondary cores having no deformation and being perfectly shaped as the drawings, which was not always possible according to the traditional technology, since often inside shapes of a main core box requires mobile parts for drafting, which can only be obtained with special deformation.

In any case, the casting designer is provided with a new technology that allows obtaining castings which can even embed other adjacent parts currently casted separately, according to the constraints of the current traditional casting technology.

Such new technology can also be used for obtaining stiffening by pre-coating fragile cores with foamed material in order to facilitate handling or for a greater protection against breakage after pre-assembly into the mould, or for restricting the effect of metallostatic pressure.

The above is obtained both by performing a pre-assembly

directly into the die, and in this case the coating thickness may be equal to or smaller than the casting thickness, or by laying the pre-coated cores into another core box yet to be moulded, and in this case the coating must be equal to the casting thickness.

In order to coat both cores and inserts with polystyrene or other equivalent material, it is necessary to be provided with a specific die consisting of a single lower negative half and another upper negative half, since positive patterns consist of the cores or inserts to be coated.

The die is constructed with all core print seats equal to the core boxes, to moulds or chills, considering the specific tolerances and thermal expansions.

<u>Detailed description of an embodiment of the invention</u>

The casting procedure described is especially but not exclusively adapted to be applied to a chill casting process of an engine cylinder head. In this case, with reference to the attached drawings, the main core 11 is the water jacket core that is that intended to realise the coolant circulation passages, whereas secondary cores mainly are those relating to the intake 12 and exhaust 13 duct.

The latter, plus any other secondary cores, such as for example those intended to create the exhaust gas circulation compartment and that somewhat involve the water jacket core,

are moulded into respective core boxes in a traditional manner. Once moulded, such cores are laid into a single die 19 (Fig. 4) to be coated with foamed material 18, such as polystyrene. Valve seats 14, 15 for the intake and exhaust valves, may be previously laid into said die, at special references. Moreover, the die may be provided with mobile cylindrical pins 16, 17 intended to realise seats 16', 17' (Fig. 5) for the valve guides 16", 17".

Polystyrene 18, or equivalent material, injected into the die, only envelops the shaped zones of the cores inserted therein , with the required casting thickness, thereby excluding the core prints 12', 13'. Also the valve seats onto the outside diameter are embedded, whereas inside they will be aligned on the conical edges of the duct cores. For this specific application, the valve seats 14, 15 must have the proper machining stock on the inside diameter. The outside diameter of the valve seats is realised with a taper equal to the inside one, and such taper is required for the coating material to support and held into position the valve seats during further handling, up to the assembly into the chill or die. The metal will then finally block the valve seats onto the casting.

The group consisting of ducts 12, 13 and of the valve seats 14, 15, all coated with foamed material 18, and therefore consisting of a single body (Fig. 5) is then laid (pre-assembled)

into the water jacket core box 20 (Figs. 6, 7). As said above, the water jacket core box 20 exhibits very simple structure since it is free from the shapes corresponding to the outside thickness of pre-assembled secondary cores.

In fact, in place of such shapes there are reference seats 20' and negative prints 20" (Fig. 6) intended to receive the secondary cores with the relevant prints and the valve seats coated with foamed material. The core box therefore is free from any undercut and mobile parts.

At this point the water jacket core box is filled with sand and polymerised resin, thereby obtaining a very accurate monolithic group wherein the water jacket core 11 envelops and holds the outside thickness of the duct cores consisting of the foamed material on the shaped zones (Fig. 8). A perfect relative positioning between each core is therefore obtained as well.

When the entire group consisting of secondary cores, valve seats and foamed material has been moulded into a single body with the water jacket core, the valve guides 16", 17" can be automatically inserted into the suitable seats 16', 17' obtained in the foamed material. Special sealing members are applied to the junctions between foamed material and upper half water jacket core box in order to prevent sand infiltrations into the guide seats during moulding.

The valve guides will be solid (without central holes) since mechanical machining for inserting the valve stems is performed with valve guides embedded into the casting. Among the other things, this allows preventing the use of traditional stiffening bosses around the valve guide into the duct cores.

The valve guides will be provided with a negative circular groove at the portions embedded in the foamed material, which will hold into position the valve guides in the casting metal when the latter replaces the foamed material.

In the upper portion of the valve guide there is often another core 21 for the oil gallery, as in the case shown in fig. 10, or a core for the tappet compartment, which realises the risers (casting metal feeding during the shrinkage by cooling).

As a consequence, the upper end of the valve guides will always be guided into a suitable seat realised into said upper core 21 or into the tappet compartment core, and therefore blocked into the correct position, even when the casting metal has dissolved or is dissolving the foamed material around the valve guides, without making the same valve guides collapse.

In the lower portion, the valve guides are inserted and stopped into suitable seats 22 obtained in the duct cores (Fig. 3).

At this point, the monolithic group comprising the water jacket core 11, the secondary cores, the valve seats, the valve

guides, the foamed material along with other cores, such as core 21, can be laid assembled into the chill (Figs. 9, 10). During the casting, the molten metal will dissolve and replace the foamed material, determining the required thickness and embedding the valve seats and the valve guides.

Fig. 10 shows the same assembly scheme described above, but where the duct cores consist of metal hollow inserts 23 (or made of another material capable of standing the heat generated by the casting metal), filled with sand and polymerised resin having a support function as well as serving to prevent any penetration of molten metal into the inserts. The interior of such inserts has the same dimensional features of sand cores. Polymerised sand cores and inserts 23 are moulded into a specific core box 10 which must keep into account the thickness of said inserts (Fig. 2).

At one end, the inserts end against the valve seats whereas as the opposed end, they end flush with the casting raw flange.

Since the intake and exhaust duct cores 12, 13 and any other secondary cores are laid (pre-assembled) after having been coated with foamed material 18 in the water jacket core box 11, there is no design limit for the ducts or for other secondary cores. For example, the intake ducts may be connected to one another with a single chamber without any interruption in the horizontal direction to the upper parts of the valve seats. Such

chamber may even reach the intake manifold coupling flange and form a single chamber integral with the same manifold, without implying any problems of assembly with the water jacket. Such concept may also be extended to inserts made of another material and embedded into the casting.

As a consequence, the head designer will have a wide freedom of design since the current design constraints are eliminated, such as the forced passage of the ducts through the water jacket. For example, as shown in Figs. 9a and 9b, the water jacket compartment can be realised with more rounded design (black parts) in place of the current inclined surfaces and sharp edges to allow drafting. The outside duct core thickness is also free from deformations, with a constant and perfect thickness exactly as drawing specification.

In short, the chill casting procedure proposed and applied to the realisation of an engine cylinder head allows obtaining the following advantages:

- intake and exhaust ducts without any inside design constraints and without deformations on the outside thickness, with consequent constant casting thickness;
- intake and exhaust ducts consisting of heat resistant inserts and embedded during casting;
- higher geometrical accuracy in the position of the intake and exhaust ducts and of the water jacket relative to the

combustion chambers;

- water jacket with a greater water passage volume in the more critical zones;
- valve seats embedded during casting;
- valve guides embedded during casting;
- possibility of eliminating the holes created by the prints for supporting the water jacket core in the pouring step, thereby eliminating the mechanical machining required to plug such holes.